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H 109 Gives the Highest Yields.

OAHU SUGAR COMPANY, EXPERIMENT NO. 5, 1920 CROP.

In this experiment the following varieties of cane were compared: H 109, H 456, Striped Mexican, and Badila. H 146, H 227, Yellow Caledonia, and Lahaina were also included in the experiment, but they did not do well and on account of the lateness of the season and difficult labor conditions they were not harvested as part of the test. H 146, which did so well in this field two years ago as plant cane, has since developed Lahaina disease and is not to be recommended for any regions where Lahaina disease is likely to be present.

This crop was first ratoons, long, being the second crop from virgin land. The field is at about 550 feet elevation and irrigated with mountain water.

The 1918 crop was harvested in March, 1918, and the ratoons cut back on July 7, 1918. The Badila was not cut back.

The 1920 crop was harvested in November, 1920, the cut-back varieties being 28 months old and the Badila 31 months. From January, 1920, to the time of harvest this field was not irrigated and was rather dry at time of cutting. The rainfall during this period amounted to 23 inches, but with the exception of 5.40 inches in January and 5.07 inches in March, none of this rain was in sufficient quantity at any one time to be of any great value to big cane—that is, all the other rains were of less than half an inch each.

The results obtained from the different varieties were as follows:

Variety	Yield per Acre (Tons)		
	Cane	Q. R.	Sugar
H 109	97.39	7.61	12.80
H 456	76.61	7.26	10.55
Striped Mexican	79.20	7.58	10.45
Badila	79.89	8.47	9.43

The H 109 produced over two tons of sugar per acre more than any other variety. H 456 was second in yield and had the best juices. It is well to note here that H 456 was plant cane, having replaced H 333 on account of eyespot on the latter variety. The planting was done on June 26, 1918. The old stools were dug out by hand and the seed put down in the same place. No plowing was done. Body seed was used, some of which was very hard. The seed germinated very slowly and very poorly. On account of lack of seed it was impossible to do any replanting. As a result the stand was poor. When comparing the results obtained this slower start and poor stand should be borne in mind. The Badila did not do very well on these upper lands. It was probably too old when harvested. At time of harvest Badila had the poorest juice of the lot; there was also a considerable amount of dead cane.

Although not in this experiment, D 1135 in adjoining tests gave yields very nearly as good as the H 109. The quality of the D 1135 juices was remarkably good, better than Lahaina juices in adjoining plots receiving similar treatment.

J. A. V.

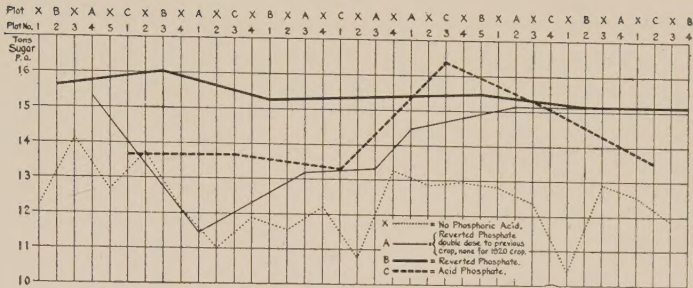
Phosphoric Acid for the Upper Lands on Oahu.

OAHU SUGAR COMPANY, EXPERIMENT NO. 6, 1920 CROP.

SUMMARY.

In this experiment a study was made of the value of different forms of phosphoric acid in addition to nitrogen for the upper lands (550 feet elevation) of Oahu. The crop was H 109, first ratoon, long. This is the second crop raised on these lands, the plant crop having been from virgin land.

CHART SHOWING YIELDS BY PLOT FOR EACH TREATMENT.
OAHU SUGAR CO. EXP. 6, 1920 CROP



The treatments were as follows: all plots received 175 pounds of nitrogen per acre, applied in four equal doses, in August and November, 1918, and February and May, 1919. In addition to this the A plots received 1143 pounds per acre of reverted phosphate (180 pounds of P_2O_5) for the 1918 crop. This was intended to last for two crops. No phosphate was added to the A plots for the 1920 crop. The B plots received 643 pounds of reverted phosphate (90 pounds P_2O_5), while the C plots received 474 pounds of acid phosphate (90 pounds P_2O_5).

The results obtained from the two crops, one plant and one long ratoons, are given as follows:

1918 CROP — PLANT.*

Plots	Treatment	Yield per Acre			Gain Over No Phosphoric Acid	
		Cane	Q. R.	Sugar	Cane	Sugar
X	No phosphoric acid	67.38	9.53	7.07
A	180 lbs. P_2O_5 from reverted phosphate	75.45	9.62	7.84	8.07	0.77
B	90 lbs. P_2O_5 from reverted phosphate	75.85	9.28	8.17	8.47	1.10
C	90 lbs. P_2O_5 from acid phosphate	80.88	9.63	8.40	13.50	1.33

* For details of the 1918 crop see Planters' Record, Vol. XIX, page 142.

1920 CROP — FIRST RATOON, LONG.

Plots	Treatment	Yield per Acre			Gain Over No P_2O_5	
		Cane	Q. R.	Sugar	Cane	Sugar
X	No phosphoric acid	86.9	7.02	12.38
A	No phosphoric acid 1920 crop; 180 lbs. P_2O_5 1918 crop	101.1	7.22	14.01	14.2	1.63
B	90 lbs. P_2O_5 from reverted phosphate	103.1	6.70	15.46	16.2	3.08
C	90 lbs. P_2O_5 from acid phosphate	102.1	7.14	14.29	15.2	1.91

The A and B plots received the same amount of P_2O_5 from reverted phosphate for the two crops, but in the case of the A plots it was all applied to the plant cane, and none to the ratoons; for the B plots the P_2O_5 was equally divided between the plant and ratoons. Dividing it between the two crops gave the best results for both crops.

There was very little difference in the yield of cane from the different series of plots receiving phosphoric acid. But it is interesting to note that for both crops, the B plots getting 90 pounds of P_2O_5 per acre from reverted phosphate had the better juices, thereby producing the most total sugar.

FORMS OF PHOSPHORIC ACID.
OAHU SUGAR Co. Exp. 6, 1920 CROP
FIELD 45.



SUMMARY OF RESULTS.

Treatment	No. of Plots	Yield Per Acre, Cane, q. c.	Yield Per Acre, Sugar, cwt.	Cal. Juice, %
X 19 No Phosphoric Acid	1	8634	7.02	12.39
A 7 No Phosphoric Acid 1820 Crop, 1820 Ratoon, 50% P ₂ O ₅ from Reverted Phosphate	1	10112	7.22	14.01
B 6 90* P ₂ O ₅ from Reverted Phosphate	1	10309	8.70	15.46
C 6 90* P ₂ O ₅ from Phosphoric Acid	1	10205	7.14	14.29
				15.11
				19.1

DETAILS OF EXPERIMENT.

1. Reverted phosphate.
2. Super-phosphate.
3. No phosphate.

Object—To determine the value of applying reverted phosphate as against applying acid phosphate or no phosphate.

Location—Oahu Sugar Company, Field 45, Koalipea Section, Division No. 1, on both sides of the straight ditch that runs through the experimental area of the field.

Crop—H 109, first ratoon, long.

Layout—No. of plots, 38.

Size of plots, each 1/22 acre (36'x 55'), consisting of 10 single rows, each 5.5' wide and 36' long. Each plot 1 watercourse in width. Each single row 1/220 acre. These areas include watercourses. For level ditches and straight ditches add 2.5%.

Plan—"A" plots=180 pounds per acre of P_2O_5 as reverted phosphate applied before planting the last crop. (To last for two crops.)

"B" plots=90 pounds per acre of P_2O_5 as reverted phosphate, applied August, 1918.

"C" plots=90 pounds per acre of P_2O_5 as acid phosphate, applied in two equal doses (August, 1918, and November, 1918).

"X" plots=No phosphoric acid.

All plots to receive 175 pounds per acre of nitrogen in four doses, as follows:

244 pounds per acre of N.M. August, 1918.

244 pounds per acre of N.M. November, 1918.

244 pounds per acre of N.M. February-March, 1919.

241.6 pounds per acre of N.M., May-June, 1919.

N.M.=Nitrogenous mixture: 18% nitrogen— $\frac{1}{2}$ sulfate of ammonia and $\frac{1}{2}$ nitrate of soda.

Detail of Work—

1918 crop harvested in March, 1918.

1920 crop cut back July 7, 1918.

First fertilization August 31, 1918, by Kutsunai.

Second fertilization November 8, 1918, by Kutsunai.

Third fertilization February 19, 1919, by Kutsunai.

Fourth fertilization May 26, 1919, by Kutsunai.

Experiment harvested in November, 1920, by Kutsunai, Pauhau, with Kabori helping. All juices sampled at crusher in carload lots by Bomonti.

J. A. V.

The Mineral Requirements of Plants.*

By H. F. BERGMAN.

All plants require for their normal development certain chemical elements such as carbon, hydrogen, oxygen, nitrogen, potassium, phosphorus, sulphur, magnesium, calcium, and iron. All of these are not used to an equal extent, but no one of them may be lacking without in some way interfering with the normal development of the plant. Of these elements only one, oxygen, is capable of being absorbed in a free or elemental state. The others are absorbed as chemical compounds which must be soluble in water in order to be taken into the plant. In general they occur and are absorbed as nitrates, phosphates, sulphates, and carbonates. The plant shows no preference among these forms in absorbing materials provided that all the essential elements are supplied.

Carbon is very widely distributed in nature, occurring as carbon dioxide in the atmosphere and as *carbonates* in the soil. It is the most abundant constituent of the dry matter of the plant, making up by far the greater part of the dry weight. All the carbon in the plant body is taken from the atmosphere. Although carbon exists in the soil as carbonate and is absorbed by the plant, the *carbon* in such absorbed *carbonates* is not utilized in building up the *carbonaceous* matter of the plant body.

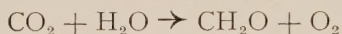
In the atmosphere there is present about three or four parts of carbon dioxide in ten thousand parts of air. Yet it is from such a dilute mixture that all the carbonaceous material in the dry matter of the plant is built up. When we consider that for each ton of green plant material 80-90 per cent is water and of the remaining 10-20 per cent the larger part of it is carbon, we may get some

* A lecture presented at the Short Course for Plantation Men, October, 1920.

idea of the immense volume of air required to supply this amount of carbon. Of these two most extensively used materials, water and carbon dioxide, there is fortunately an abundant supply, so that they are not often lacking.

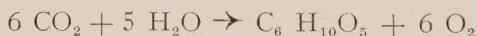
The carbon dioxide of the atmosphere is absorbed by the leaves and green parts of stems through microscopic openings, called stomata, which occur in the epidermis. In a very large number of plants the stomata occur only on the under side of the leaves. Some plants have stomata on both upper and lower sides. In some instances the distribution is equal, in others there may be more on the lower side than on the upper, and in a few cases the greater number appears on the upper surface.

The air enters the stomata, after which it comes in contact with the moist walls of the cells in the interior of the leaf. It then goes into solution in the water and passes through the cell wall into the cell. There occur within the cells of the leaf green bodies or chloroplasts which in the presence of light have the ability of combining the carbon of the absorbed air with water to form carbohydrates. The reaction in its simplest form may be indicated as follows:



The product CH_2O is *formic aldehyde* and is regarded as the first step in the formation of carbohydrates. By combining several molecules (polymerization) a more complex molecule is formed. Thus if six molecules of CH_2O were combined into one we would have $\text{C}_6\text{H}_{12}\text{O}_6$, which is known as glucose, dextrose or grape sugar. If two molecules of glucose are combined and one molecule of water abstracted we have $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, or cane sugar. The plant is able to make the simple combination first indicated, and then by polymerization to make the more complex substances *glucose* and cane sugar or starch. Starch is similar in composition to glucose, the most commonly assigned formula being $(\text{C}_6\text{H}_{10}\text{O}_5)_n$. By adding a molecule of water, starch may be converted into glucose, $\text{C}_6\text{H}_{12}\text{O}_6$.

It will be seen that for each molecule of carbon dioxide taken in, one molecule of water is required, and one molecule of CH_2O is formed with the liberation of one molecule of oxygen. Or if we consider starch as the final product the reaction might be indicated as follows:



For each molecule of starch six molecules of carbon dioxide are required with the liberation of six molecules of oxygen. This process of carbon assimilation, or photosynthesis, can take place only in green parts of the plant and only in the presence of light. The hydrogen and oxygen used in the formation of carbohydrates is derived from water, and it will be observed by reference to the equations given above that hydrogen and oxygen are always combined in the proportion in which they occur in water. The water used in this process is absorbed from the soil by the roots.

The materials so far considered are used in the formation of carbohydrates. In addition to these every plant must be supplied with nitrogen in some form for the formation of proteids. Proteid substances constitute the bulk of the protoplasmic material of which the plant consists. In addition to carbon, hydro-

gen and oxygen, all proteids contain nitrogen and sometimes also phosphorus and sulphur. Nitrogen also appears in other compounds present as plant constituents.

Although nitrogen makes up about four-fifths of the volume of the air and is absorbed by the plant with other constituents of the air, none of this atmospheric nitrogen can be utilized by plants. All the nitrogen necessary for plant metabolism is taken up from the soil as nitrates or as ammonia or other compounds readily convertible into nitrates. The higher or flowering plants cannot utilize nitrogen to any extent except as nitrates. This applies even in the case of leguminous plants. These indirectly make use of atmospheric nitrogen, and for this reason are valuable for adding nitrogen to the soil. The bacteria in the nodules on the roots of leguminous plants convert free nitrogen into ammonia compounds, then to nitrites and finally into nitrates, thus making the nitrogen available to the plants on the roots of which the nodules occur.

Proteid formation, like carbohydrate synthesis, takes place largely in the leaves, although, unlike the latter, it is not dependent on light nor is the action of the chloroplasts necessary. Proteid formation goes on at night as well as in daylight, and may occur in any part of the plant. The localization of this process in the leaves is probably due to the fact that an abundant supply of carbohydrate material is present from which proteids may be synthesized.

The remaining elements are the so-called ash constituents, since they are left when the plant is burned. Of these, phosphorus and sulphur are used in the formation of proteids of which the protoplasmic substance is built up. The nucleus of cells is especially rich in phosphorus.

Phosphorus must be in the form of phosphates to be available to the plant. The primary and secondary phosphates are more soluble than the tertiary, and hence are more readily available. On account of their greater solubility the primary and secondary phosphates are more apt to be leached out of soils by heavy rains. For this reason it is sometimes better to apply tertiary phosphate when a deficiency of this element exists. This is sufficiently soluble, especially when carbon dioxide is present in the soil water, even to as slight an extent as 0.03 to 0.04 per cent, to supply the requirements of the plants.

Potassium is relatively abundant in young tissues. The exact function of this element is not agreed upon. It may be connected with the formation of carbohydrates and proteins. Evidence indicates that when potassium is not supplied, starch formation does not take place. Similarly, in the absence of potash, proteid formation does not occur even when the plant is supplied with sugar. It has also been shown that seeds or other parts of the plant rich in proteins are also high in potash. Other investigators claim that it is largely concerned with the maintenance of turgor in plant cells. Whatever its exact function may be, it is indispensable and cannot be replaced by sodium or other elements.

The function of calcium and magnesium is likewise not well defined. Magnesium has a distribution and importance somewhat similar to that of potassium, as it occurs abundantly with the latter in young tissues. Its main function is probably in the conveyance of phosphoric acid for assimilation. Magnesium is also utilized along with potassium salts in the maintenance of turgidity. Calcium is in some instances apparently necessary in the formation of cell walls.

Calcium is also commonly present as calcium oxalate in many plants, and therefore one of its functions may be to neutralize the oxalic acid formed in metabolism and thus prevent injury to the plant by the accumulation of this acid. Certain experiments have shown that calcium is in some way necessary for starch digestion, and some later investigators assign to calcium an active function in the formation of certain compounds as a necessary preliminary in the construction of proteins. In spite of the fact that the exact manner in which these elements are used by the plant is not clear, it is well known that if they are not supplied the plant is unable to make normal growth.

Iron, although required in less quantity than many other elements, is highly important to the welfare of the plant. It is necessary for the maintenance of the chlorophyll upon which photosynthesis depends. If iron is not supplied, the plant becomes yellow. In this condition the chloroplasts are inactive and cannot assimilate carbon dioxide. Apparently a plant can make use of any iron compound that is soluble, hence it makes little or no difference as to the form in which iron is supplied.

Certain substances in the soil sometimes nullify the effect of iron in some way. This seems to be true in the case of manganese with pineapples. Where the soil contains a high manganese content the plants are unable to absorb or utilize the iron compounds in the soil, so that they soon become yellow or sickly in appearance. An application of an iron salt, usually sulfate, as a spray on the leaves has been found to be an efficient remedy.

Many substances not necessary to the growth of the plant or usable by it may, however, find their way into the plant in moderate or large quantities. Similarly, the necessary elements may be absorbed in quantities greater than can be used if abundantly present in the soil. Even substances injurious to the plant will be absorbed from the soil if present there in soluble form, as the plant cannot select the desirable materials and exclude others which are not desirable or which are injurious.

All materials in the soil in soluble form are taken in through the epidermis and root hairs on the younger portions of the root by the process of osmosis. Osmosis is the passage or interchange of substances between solutions of unequal concentration separated by a non-porous membrane. By non-porous is meant that there are no openings or pores evident even when examined with the microscope. If an interchange is effected there must be passageways, but these are only of molecular dimension. All substances are composed of molecules, which are constantly in motion and never in contact with each other, so that very minute inter-molecular spaces are present. Substances in solution become separated into molecules or these often dissociate into ions.

In the case of a plant growing in soil, the epidermis is the separating membrane. The soil water with the various dissolved mineral salts constitutes one solution and the cell contents the other. The mineral salts being more abundant outside the plant than inside makes an osmotic interchange possible. In osmosis the interchange is from the more concentrated to the less concentrated solution, and continues in this direction until the concentrations become equalized on both sides of the membrane.

Any substance in the soil if soluble in water may enter the plant ordinarily. The molecules of a substance in solution move about freely, so that some molecules strike the intercellular spaces of the membrane (cell wall), penetrate through these spaces and gain entrance to the cell. This is true regardless of the fact as to whether the entering substance is beneficial, inert or injurious to the plant. After entering the epidermis the substance osmotes from cell to cell and finally reaches every living cell in the entire plant.

If the entering substance is one which is necessary for the growth of the plant it is at once changed into some other form or used up. It is thus thrown out of circulation, so that more substance continues to be absorbed from the outside. This will continue as long as that particular substance is being used by the plant. If supplied more rapidly than the plant can use it, the substance will enter until the concentration of the substance becomes the same in the cell sap as in the soil solution outside. The same would apply to substances for which the plant finds no use except that such materials would not be transformed and would enter only until the concentration within the plant has become equalized with the soil solution with reference to that substance.

The absorption of any given substance may take place independently of the movement of any of the others. Thus, if a plant requires nitrate and nothing else for a time, only nitrates would be absorbed. This is due to the fact that the nitrates upon entering the plant are converted into some other substance. In such a change they lose their identity as nitrates, so that as long as they continue to be transformed the concentration of nitrates in the cells of the plant never reaches that of the soil solution and therefore nitrates continue to be absorbed. This is the so-called "selective absorption" of plants, and means only that substances will be absorbed more or less continuously if needed in the metabolism of the plant, otherwise only until the concentration of these substances inside the plant has become the same as in the soil solution outside. It does not mean that plants can choose substances useful to them and exclude those which are not useful or injurious. The inability of plants to "select" foods in their sense is shown by the fact that if copper or zinc salts are supplied they will be absorbed and result in the death of the plant.

Boiling-house Methods.*

H. S. WALKER.

A Committee on Boiling-house Methods was appointed at the 1919 meeting of the Hawaiian Chemists' Association to replace the former Committee on Evaporation and Boiling, Curing and Marketing, and Clarification and Filtration, and to cover in general the entire work of the boiling house.

* Presented at the Eighteenth Annual Meeting of the Hawaiian Chemists' Association, held jointly with the Hawaiian Engineering Association, November, 1920.

Letters were sent out during the summer to the men in charge of this work, and to all the plantations, requesting their cooperation especially along the line of new ideas or new methods tried out during the year. No definite list of set questions was put forth, but the following topics were suggested for discussion:

Clarification—Effect of temperature.

Evaporation—Chemical means for removing scale from evaporator tubes.

Boiling—General Methods—It has been suggested that we adopt a standard system of sugar boiling which, of course, would have to be deviated from according to the equipment of individual factories. In order to bring out discussion on this subject, I submit for your criticism the following method, which is a slight modification of the one used at Pioneer for a number of years:

STRIKE 1A: Start on a magma of low-grade sugar and syrup. Build up and finish with syrup and remelt. No molasses boiled in this strike.

STRIKE 1B: Start as for 1A and finish by taking back all the molasses from 1A.

STRIKE 1C: Start as for 1A, and finish by taking back all the molasses from 1B.

STRIKE 2: Boil all the molasses from 1C to grain for the crystallizers.

Stated more briefly, the method consists in making every third strike from straight syrup and remelted sugar, and boiling back all the molasses twice. With syrup purities between 85 and 88 this method works fairly well, yielding a 1C molasses of from 50 to 54 apparent purity without any calculation or attempt to boil to fixed purities. With initial purities below 85, strike 1C may be omitted, as the 1B molasses will be low enough to boil for the crystallizers.

I am not putting this forth as the ideal method; if you do not approve of it, please state why, and why the method used in your own factory is a better one.

Boiling—Low grade—Different methods of graining. Causes and prevention of "false" grain.

Crystallizer work—Time required for complete crystallization; effect of temperature; effect of adding water to a massecuite on the resultant purity of molasses. Is it possible in any way to add water to a low-grade massecuite without raising the purity of the molasses? In other words, if on account of limited centrifugal capacity a factory cannot dry its low-grade massecuite at a higher density than 95° Brix, is there any advantage in boiling to 99° Brix and subsequently diluting to 95°? If so, when and how is the best time to add the water? What advantage is gained by long slow boiling of low grades? Given two massecuites of the same final Brix, purity, and number of grains; if one has taken 24 hours to boil and yields a molasses, separated hot, of 35 apparent purity, while the other was boiled in five hours and yields a separated hot molasses of 42 apparent purity, will there be any difference in the ultimate purity of the two molasses after two weeks in the crystallizers?

The following replies were received:

From Mr. A. Fries, Hawaiian Sugar Co.:

In reply to your request for a contribution to the report of the Committee on Boiling-house Methods, and following your general suggestions, I submit the following:

During the past year no methods of manufacture have been introduced in the operations at Makaweli which differ essentially from those in use at other factories. Some sug-

gestions made at the last meeting of the Hawaiian Chemists' Association have been tried out, with varying degrees of success. What interested me particularly, however, is the differences obtained by identical methods of operation here and during my engagement at Lahaina. I have no theory as to the causes of these differences outside of the variation in the nature of the juices. In this report I shall follow out, as far as possible, comparisons of work in the two places, and believe that this may be of value and interest to your report.

BOILING.

The method outlined in your request for a report is essentially that used by me while at Lahaina, and continued at Makaweli. There are so many points in its favor that they far outweigh the one objection that can be urged against it, viz: the fact that three sugars of different polarizations are turned out. This is a difficulty more for the refinery, but should not be a very serious objection, inasmuch as the sugar received from the factories, as operated now, differs more widely than the sugar from an individual factory operating under this method.

The advantages mainly are:

It gives a system to the whole process of boiling, which is very simple and is readily taken up by the unskilled pan operator.

Less boiling, and consequently a saving of fuel, and also greater capacity in the boiling department. It is well known that more sugar can be turned out under the same conditions of equipment and steam supply when more than one grade of massecuite is boiled to. Or, in other words, it is easier to get rid of a definite quantity of syrup if one boils the first strike to, say, 85; the second to 80, and the third to 78 purity massecuite, than by making all strikes 78 purity.

The taking back and reboiling of molasses is brought to a minimum, as under ordinary conditions every third strike gives a molasses of such purity as to be ready for the crystallizers, which therefore is undoubtedly much less gummy than when all strikes are boiled to 78 purity or lower.

BETTER CRYSTALLIZER WORK.

In the modification of the method Mr. Walker takes all of the molasses from strike two into strike three, and I doubt if this will always work as satisfactorily. Instead of taking all of this molasses back into the next strike, I prefer to limit this amount so that a purity of molasses is obtained which is considered suitable for crystallizer work, as otherwise the purity may come below this set standard, and result in a slower drying sugar, without the compensating lower purity of final molasses.

In respect to the crystallizer strikes, I have noticed a very important difference in the massecuite here at Makaweli and that at Lahaina. Although boiled under the same conditions and of syrup of similar purity, the massecuite is, on the whole, far freer and less viscous than that at Lahaina. We are able to purge the low grades in less time, getting a higher purity melt and a final molasses from two to three points lower in purity. Others have observed that while it is possible to do very good work in one factory, the same sugar boiler will find it impossible to get equal results at some other factory, though equipment and conditions are alike. This is due to the peculiar quality of the juices. Probably the nature of the impurities if better understood would give a more satisfactory explanation.

With the exception of a few weeks at the beginning of the crop, we have been "shock seeding" our low grades. There is no doubt as to the benefit of this method in our case. An even, square grain is obtained which grows rapidly and regularly, and it is only when accidental conditions occur that we get false grain. I do not know whether this method of "shock seeding" operates as actually introducing seed, or whether it is producing a condition of supersaturation, but I am satisfied as to the advantages.

CRYSTALLIZERS.

During the past season we have worked all our low grade in the 16 crystallizers without using the outside tanks. The crystallizers are "U" shaped, and hold 750 to 800 cubic feet under working conditions. The stirrer makes 0.3 revolution per minute, and the massecuite remains from 8 to 12 days.

For this crop we have tried to maintain a Brix of close to 98 in the low-grade massecuite, whenever possible. With inferior juice this cannot always be carried out on account of the sticky nature of the molasses. The improvement in the low-grade work this year is due to the higher density boiled, coupled with a better grain following "shock seeding," and the method of boiling first massecuite, as stated above. Better results are obtained by boiling to a high Brix, and then diluting to a lower Brix after several days in the crystallizers than by dropping the massecuite from the pan at this same low density.

We dilute from 94 to 95 Brix with water, as without it we would have difficulty in purging. With more centrifugal capacity for low grades, and consequently less dilution of the massecuite, better results as to the final molasses could be obtained, as every addition of water increases the purity of this molasses—very slightly, perhaps, when small quantities are used, but considerably when the massecuite is purged at the density of 93 or lower.

Another thing which has contributed to a better exhaustion of the molasses is the slower time of boiling. Since a new pan was put in for handling first massecuites, there have been two pans of about 800 cubic feet capacity each, available for the low grades. This allows nine hours for forming the grain and filling the pan, and four hours for building up after cutting, or a total of 13 hours. I should judge that a massecuite boiled for 24 hours could be boiled at a much lower temperature than one struck in five hours, and that after 10 days the former will not only yield a lower molasses, but will dry much more readily.

The following table gives an average of the season's crystallizer work:

CRYSTALLIZERS—CROP 1920.

	Over 96 Brix	Over 97 Brix	Over 98 Brix	Over 99 Brix
Per cent of total.....	10	35	40	15
A. P. Mol.	30.5	30.3	29.5	28.8

FILTER PRESS WORK.

The work at this station at Makaweli, compared with Lahaina, offers a remarkable contrast. It must be mentioned here that the station at Lahaina was composed of the latest type of filter presses, and better results were naturally to be expected, but I feel convinced that the difficulties experienced here were due mainly to the quality of the settlings.

During the season of 1917 Lahaina had only four presses of 800 square feet filtering surface each. There was at no time any difficulty in getting away with the settlings, or in keeping up the low sugar content of 1% in the cake. Mr. Walker in his last year's report on Standardization says:

"I know of no reason why we need so much less filter area at Pioneer. Possibly it is in the nature of the juice."

I will admit that the presses here are not of the latest type, which will account for some of the difficulties in sweetening off satisfactorily. However, as the sugar content varied between 1.5 and 5%, the cause must be looked for, partly in the nature of the material to be filtered, and partly in the equipment itself. In order to reduce the sugar content, four resettling tanks were put up in the early part of the season. A few previous experiments showed that this resettling could be accomplished in good time, but after actually working the process for a few weeks, with varying applications of heat and lime, we found that some scums would resettle nicely, others poorly, and most of them not at all, and we discontinued this resettling, as the sugar content of the press cake remained equally high.

At Lahaina I believed that the amount of cush-cush in the mixed juice was responsible for the good filtration and the easy extraction of sugar. We have tried larger perforations in the juice screens, and even added cush-cush to the settlings here, with no result. Equally of no advantage were the experiments with a phosphoric acid clarifier, or with a complete change in the filter cloth material. On some occasions the settlings would filter nicely, and fill the frames in good time, but after about half an hour of water pressure the presses refused to let any water through. The presses were filled, as at Lahaina, from a supply tank 25 feet overhead, and sweet water was forced through for about one hour under a pressure of 40 pounds, then clean water for two hours under a pressure of 50 pounds, the total time for sweetening off being three hours as against one and a half hours at Lahaina. Our average sugar in the press cake this year is 3.82%, while Lahaina will probably be below 1%.

These differences at the two factories open an interesting problem. The mixed juice is divided into clarified juice and settlings; the juice evaporated to syrup, and massecuite works more easily at Makaweli than at Lahaina, particularly in regard to low grades, while the settlings collected in the filter presses are far more refractory and difficult. If a research could be made into the entire composition of the whole juices and separated products of two such places as above, some interesting light might be thrown on some of the uncertain phases of sugar manufacture.

From Mr. J. W. Donald, Kekaha Sugar Co.:

BOILING—GENERAL METHODS.

The method of systematically boiling mixed strikes of syrup and molasses, developed in Java and referred to a few years ago as "The Java Process," had for its original aim the production of only one grade of massecuite which would yield shipping sugar and waste molasses. This aim has never been practically attained, even in Java, owing to the high density of the massecuite, the consequent difficulty in handling and purging it, and the excessive amount of washing required. But the modification of it in which two grades of massecuite are produced is in very general use in every sugar-producing country. In this method, the proportions of syrup and molasses in the first strike are so arranged that the massecuite will always have approximately the same quotient of purity—as also the resulting molasses. No calculations on the pan floor are required. A table is prepared for the use of the sugar boiler showing at a glance the proportions of syrup and molasses (according to the purity of the syrup—the molasses purity being approximately constant) which must be used to obtain a massecuite of the desired quotient.

The causes of fluctuation in the purity of the molasses are frequent changes in the purity of the syrup and variations in the density to which the massecuite is finally brought before striking. This latter difficulty is very slight with skillful pan men, and is, in any case, common to all methods of boiling.

This is a neat, simple and scientific *modus operandi*, and the great advantage it has over the method you outline in your circular is that there is only **one** A massecuite and **one** A molasses. Pan men, centrifugal men, and all others, do not have to change their procedure from one strike to another; they are always handling the same material and can always work the same way. All the molasses storage capacity required is just what is sufficient for one strike of A and one of B.

EVAPORATION—REMOVING SCALE.

Any ordinary incrustation will be dissolved or at least broken down and left as a mere slime by caustic soda without any other agent, mechanical or chemical, particularly where the scale is largely composed of silicates and organic salts of lime and magnesia. The soda solution, however, must be very much stronger than is usually employed, and it must be given time. With solutions of 12.5 to 25% NaOH (1.14 to 1.275 S.G.) a heavy coating will be removed in one to five days from every corner and crevice of the effect, depending on the thickness of the scale. No heat above atmospheric is required.

I am unable to say if still stronger solutions and a boiling temperature would not enable us to get the same result in the time at our disposal between Saturday and Monday.

There are numerous scale solvents on the market under various trade names. Most of these are simply anhydrous carbonate of soda (soda ash) and cannot compare with caustic soda in efficiency. They change the silicates to carbonates, and these latter generally remain as firm a scale as the former, although they can be easily removed by an additional treatment with dilute acids.

From Mr. W. K. Orth, Koloa Sugar Co.:

EFFECT OF TEMPERATURE ON CLARIFICATION.

I found that your theory worked well with sound juices, but with juices coming from cane that had suffered deterioration or decay, the sterilizing effect of heat seems necessary for keeping.

BOILING.

I always try to get the molasses through the house with as little reboiling as possible, which is the essence of the method you describe.

LOW-GRADE WORK.

At the start of the season I boiled to a light string proof, but added sugar dust, kept on boiling up to 100 Brix, as formerly, time of boiling being about 12 hours; 27" vacuum throughout. Our cane had suffered severely by drought, and on account of the poor stand and labor conditions, we could not be particular about the soundness of the material fed into the mill. The massecuite would rise (swell, not foam) in the crystallizers to a degree never before experienced here. It would rise and stay risen, would not behave in the conventional way when a fillmass rises and slowly goes back again. I kept the juice in turns acid, neutral, and alkaline, at high and low temperature. The results were in each case much the same. The grain was very even and of fair size, but after ten days in the crystallizers and after having been thinned down with water to 95 Brix or less, it would take more than an hour to dry half a machine full. The purity of the massecuite varied from 55 to 58. However, the crystallizers kept over as experiments for 20 days would

dry well in a short time and the purity of the waste molasses would come down as low as 28 apparent. I dropped boiling to such high densities and gradually came to 96.5 Brix. The trouble was not remedied, and I changed my way of boiling.

I boiled to proof, drew in dust, stopped the pan and after due time proceeded in the familiar way. The size of grain was about the same as before, but not as even; temperatures and densities as well as purities were not changed. My previous troubles as to swelling in crystallizers were over, but a new one developed. False grain would frequently come in the crystallizers. I could not boil longer than 12 hours on account of the low purities of our juices and for other reasons, so had to do something to keep ahead of the mill. I knew from experience that this false grain could be prevented forming in the crystallizers by dropping the strike into containers that had previously been heated to the temperature of the pan and then keeping it warm until the supersaturation had worked down below the danger point. But as I had no water-jacketed crystallizers, I tried to get the same results by having about 20 gallons of water in 450 cu. ft. crystallizer when the strike was dropped in. It worked: no more small grain formed, the stuff dried well after ten days, and the purity of the waste molasses was as low as ever. My average for the season is 38.1, but that is no criterion; the quality of our juices is responsible for that high figure. I do not know why most of it should not come down to 36 as it did when I could allow a little more time in the crystallizers. To explain a little more: the massecuite leaving the pan was, say, 97 Brix; six hours after (the water being all absorbed), 96.3; two days later, 96.6. Further water added from the fifth day on until it was dried at 95. It was suggested to me not to boil as stiff or to add something to dilute the mass in the pan. These are not the same as adding the water right after striking. The desugarization should be driven as far as possible in the pan. The water added as I did serves only to prevent a dangerous rise in super-saturation due to the rather sudden cooling. The small amount of water is rapidly taken up, and even if some little sugar is melted, that would, at this early stage, not do anywhere as much harm as the fine grain.

CRYSTALLIZER WORK.

By the statement that desugarization should be driven as far as possible in the pan it is not meant that extremely slow boiling should be resorted to. As long as you boil slowly enough to have first a good foundation to build on, then have the grain grow without false grain forming, the desugarization in the pan is mainly a question of evaporating the water that keeps the sugar in solution. How long that takes and how far you may go depends entirely on local conditions, raw material, pan construction, and the skill of the pan man. To boil slower than is required to do that work is a waste of effort. Besides, I do not believe in subjecting very impure sugar solutions to the dangers of local overheating longer than necessary. Further desugarization is a question of careful temperature reduction, a work that belongs to the crystallizers.

But not only does desugarization take place in the crystallizers, but changes occur in the massecuite as well that have to be considered locally when thinking about crystallizer capacity. These changes are due to the nature of the impurities, that differ much in different places, but are more or less prevalent in the particular locality year after year. I certainly find here that the drying of a massecuite is often much improved by longer standing, even after the maximum desugarization has been reached.

From Mr. J. P. Foster, Maui Agricultural Co.:

I am enclosing a set of card forms which have been used satisfactorily at Paia for some years. They are of good quality cardboard, 5" high x 8" long, and fit a standard file. They are used for all routine control work of the laboratory, and, in our opinion, offer many advantages over ordinary record books. I enclose also a field record and a daily report to the manager. For convenience in the following references I am numbering them from 1 to 14 inclusive.

Card No. 1 needs no explanation. It presents for instant examination all the essential cane data required here at Paia. Please note the daily entry of the Java ratio.

Card No. 2 shows the method of correcting averages on products where no direct weights are available. It is grossly inaccurate to take an arithmetical average of the solids and sucrose analyses to represent the average analysis for the week, as, in so doing, the figures for a partial day's grinding of, say, 500 tons may be placed on an equality with those representing two or three times as much material.

In order to minimize this possible error, we make use of two factors derived from the weight of mixed juice. "Factor A" represents tons of solids in mixed juice, and "Factor B" represents tons of sucrose in mixed juice. The per cent solids and per cent sucrose of normal juice are multiplied by "A" and "B" respectively, and the products entered in the appropriate column on the card. At the end of the period, the totals of the last two columns are divided by tons solids and tons sucrose for the corresponding period, as found on Card No. 4, and the results entered in the first two columns as the average solids and average sucrose for the period. We do not claim this to be an absolutely true average, but

	Gross Time	Nett Time	Tons per Hour	Tons Cane.	% Sac.	% Fiber	M.I. % Cane	Tons Sucrose
Monday								
Tuesday								
Wednesday								
Thursday								
Friday								
Saturday								
T. & A.								
Previously								
To Date								

Crop of.....	Briz.	Suc.	G. P.	Factor A.	Factor B.	Briz x A.	Suc. x B.
Monday							

[illegible]

Tons Ex.	Pol.	D. P.	Tons Sucrose	Tons White	D. P.	Tons Sucrose	Total Tons Sucrose

[illegible]

Crop of	True Solids	Tons T. S.	True Purity	Tons Ash	Total Glucose	% Total Sugars	Tons Sugars

Crop of	Water in Bagasse	Fiber in Bagasse	Water in Mud	Fiber in Cane	Water in Sugar	% Water in Sugar

[illegible]

FIELD NO.	CROP OF	CROP OF
ACRES		
BEGAN CUTTING		
FINISHED CUTTING		
TONS OF CANE		
TONS OF CANE PER ACRE		
TONS OF SUGAR		
TONS OF SUGAR PER ACRE		
CANE RATIO		
VARIETY OF CANE		
FIBER IN CANE		
BRIX		
SUCROSE		
PURITY		
ESTIMATED CANE		
ESTIMATE		
ESTIMATED SUGAR		
ESTIMATE		
SUGAR.....ESTIMATE TO DATE		

DAILY REPORT TO THE MANAGER

	Crop of	th Week,	th Day.	
<i>This Date</i>	<i>To Date</i>	<i>This Date</i>		<i>To Date</i>
Mill Juice				
Sugar				
Cane				
Extraction				
Hours Grinding				
Cane per Hour				
Bagasse Moisture				
Cane Ratio				
Sugar Stored				
" Shipped				
Gals. Fuel Oil				

believe it to be much more accurate than an arithmetical average, and we believe that if the analyses of the intermediate products are worth keeping, they are worth keeping as accurately as possible.

The same method of calculation as shown in Card 2 is followed for individual cards, for first expressed juice; for last expressed juice; clarified juice; and syrup. On all other material, as cane, mixed juice, sugar, molasses, and residues, true averages are obtained from direct weights, the bagasse being referred to the cane weights. It will be noted that most of the cards have a blank column, in which other desirable data may be entered.

The use of Card No. 13, "Daily Report to the Manager," is based upon the belief that the busy manager has neither the time nor the inclination to hunt through voluminous reports in order to obtain the few items which are of daily interest to him. In this card the analysis of mill juice is entered in four groups; for example: 23.58 : 21.96 : 93.10; 21.03 : 18.80 : 89.40; 19.98 : 17.83 : 89.24; 19.89 : 17.49 : 88.02. The first group is the solids, sucrose, and purity of first mill juice for the day; the second group, the same for the crop to date; the third group is the analysis for the corresponding day of the previous year; and the last group shows the average of the previous year at the same date. Under "Sugar" is entered first the tons, then the polarization, and the same with cane. The other items are self-explanatory. This card is placed upon the manager's desk each morning, and after his inspection, is filed in a small card cabinet on his desk. It is probable that such a system, with modifications to suit individual requirements, will be more satisfactory to the managers than the usual form of elaborate report sheet.

The Field Report, Card No. 14, contains all of the essential data to each individual field, and at the right of the card is entered the corresponding figures from the last preceding harvest of the field. The blank space under "Estimated Cane" and "Estimated Sugar" are filled in "Under Estimate" or "Over Estimate," as the case may be. In the last line is entered the crop standing, in total tons over or under the crop estimate to date. The back of the card is standard ruled for the purpose of giving special data, as fertilizing or cultural operations which it is desirable to record. These cards are filed in the same cabinet on the manager's desk in which the daily reports are placed, and a very small space contains the field records for several years, which are of great value to him in making his estimates, and enable him to see at a glance data which might otherwise require considerable search to produce.

From Mr. G. Giacometti, Olaa Sugar Co.:

During the present season the only departure from our former method of boiling is the graining of the low grade with white powdered sugar in proportion to 100 cc. to 1000 cu. ft. massecuite. After working in this way for the entire season we are satisfied that it is an improvement. The grain is certainly more even and when used for seed in boiling commercial grade its influence is still more apparent. For reasons that we do not understand, it seems that sugars boiled in this way are practically free of conglomerate.

Hoping to better exhaust our final molasses we are trying to reduce the size of the grain and raise the density. It looks as if this is the right direction, but it causes such a slowing down in the curing process that it is doubtful that we can go much farther with our equipment or even keep the present standard when the boiling house is pressed.

In regard to false grain, we have been trying to prevent the formation of same in the crystallizers, or, better said, on the way from pan to crystallizers. When the strike is ready to drop it is practically free of false grain, but after a day or so in the crystallizers it is often quite the contrary. We suspect that the massecuite of high density in passing from the pan to the crystallizers is chilled, with consequent effect on the supersaturation. We have been experimenting during the past few weeks with lowering the density just prior to striking the pan. Although too early to form a definite opinion, results so far are very encouraging.

A few hours before opening a crystallizer we dilute the massecuite with a few gallons of cold water. It helps considerably in the centrifugals, and we have never been able to detect any effects on the final molasses.

From Mr. H. D. Beveridge, Onomea Sugar Co.:

1. We have obtained the best clarification of juices at 210° to 220° F., and try to average around that temperature. With a lower temperature we have found a large deposit in pre-evaporator and first cell of evaporator. We have never tried above 220° F., for fear of destruction of sucrose through overheating.

2. We boil out with caustic soda solution at atmospheric pressure and clean out with scrapers and brushes.

No heavy scale formation has been secured for several years.

3. The method described by you has the advantage of starting with fresh molasses every third strike, which is desirable.

Would the three grades of sugars have to be mingled to meet the requirements of the refiners? If so, quite a lot of extra machinery and handling would be necessary to accomplish this.

I am inclined to think the method in vogue at Onomea and most of Brewer's plantations, where we make one grade of sugar of uniform polarization and start with fresh molasses every week, as simpler and more economical on steam consumption than the method described by you.

Another method practiced at Honoumuli for several years may be of interest. Two pans were started on magma of low-grade sugar and syrup, and finished with syrup and remelt. Massecuite, 82 to 86 apparent purity; sugar, 97.8 to 98.2 polarization; molasses, 66 to 70 apparent purity. One and one-half pans dried off, all this molasses taken on half pan and struck. Massecuite, 78 to 80 apparent purity; sugar, 96.0 to 96.5 polarization; molasses, 52 to 55 apparent purity. This molasses was boiled to crystallizers. The two grades of sugars were marked and kept separate. This method gave with 86 to 88 apparent purity, syrup approximately 70% of sugars of 98 polarization, and 30% of sugar of 96.0 polarization.

4. Onomea method for boiling low-grade strikes is as follows:

Grain started in 250 cu. ft. pan with 50 to 54 apparent purity molasses diluted to 78 Brix, taken to 600 cu. ft. pan and completed, making one strike, and cut or 900 cu. ft. to each crystallizer. Boiled with exhaust steam 2 to 5 pounds pressure at 27" vacuum, 135° to 140° F. if possible. We make a practice, after the grain is well started, to take into the pan a measured amount of molasses at each charge, increasing this amount slightly as

the pan builds up, and bringing the density of massecuite after each charge of molasses to 94-95 Brix. We seldom have trouble with false grain. Although the crystals will not grow all the same size, we get a fair drying No. 2 sugar, of 81 to 83 polarization or about 86 apparent purity. We drop these strikes to crystallizer at 97 to 98 Brix.

For this kind of boiling one needs ample pan capacity, as the process is naturally slow. Taking three to four hours in the graining and 20 to 24 hours to complete one crystallizer in the striking pan, the whole time consumed for one crystallizer is from 24 to 30 hours.

5. Crystallizer Work. According to experiments made last year at Onomea and substantiated by further experiment this year, crystallization of massecuite is practically complete when the massecuite reaches atmospheric temperature, which at Onomea is from four to six days. After that time only a slight drop was noticed.

We have no data on the effect of water added to massecuite in the crystallizers, but believe it will always increase the purity of the resultant molasses.

We dilute massecuite with warm waste molasses in the magma pump on its journey to the mixer, which we think is a safer form of dilution than with pure water. By this dilution the gravity purity of the resultant molasses is raised 4 degrees. In other words, if it were possible to dry the massecuite without any crystals coming through the screens we could safely get a gravity purity waste molasses of 4 degrees lower than at present. In order to do this our present centrifugal capacity would require being doubled, and even then some of the fine grains would be forced through the screens with heavy molasses and the purity slightly raised.

I think the gain in boiling a 98 Brix massecuite and diluting to 95 Brix for purging purposes, over boiling massecuite to 95 Brix and purging without dilution, is very apparent. The 98 Brix massecuite has already crystallized out more sugar than the 95 Brix massecuite. Without the addition of water the purging qualities of the two massecuites would be nearly the same. With dilution the 98 Brix massecuite can be made to purge much more freely than the 95 Brix massecuite, with as high yield of sugar crystals better dried and of higher purity.

I have no data to bear out my statement, but do not believe it possible to remedy poor pan work in the crystallizers and would expect to see nearly the same difference or 7 degrees difference in the purity of the two molasses at the end of two weeks.

From Mr. R. J. Richmond, Hawi, Hawaii:

CLARIFICATION.

We usually heat our juices to 214° F. If we use low heat, say 180° to 200°, the clarification is not as good. Continuous settlers are used, and juice is left over night, as we work in the daytime only. This juice is heated to 180° to 200°. In the morning on starting up, it sometimes shows a loss of 2 to 5 degrees purity. On occasions when we have left clarified juice from Saturday till Monday it has lost considerably in purity, though preserved with formalin in proportions of 1:500, and alkaline to litmus paper. This may result from the juice being in contact with the settlings, and also the excelsior in the settlers, containing the solid matter caught during the week's run. For this reason I always endeavor to boil off on Saturday night.

SCALE.

For the cleaning of the effects, we use only soured molasses with an occasional boiling out with muriatic acid about once a month, cleaning out on Sundays with scrapers of brass wire fixed round rubber rings on wooden rods. If the scale is hard we occasionally have to use iron scrapers. I have used soda ash in mixed juice, half a pound to a thousand gallons, with good effect in softening this scale, but gave it up on account of cost.

SUGAR BOILING.

The system of sugar boiling used at Pioneer looks rather good to me, but would have to be tried out under varying conditions of different mills. In our system of boiling, I have noted that number one massecuites dried hot give a lighter sugar than when held in crystallizer for 24 to 48 hours.

From Mr. R. C. Pitcairn:

LOW-GRADE BOILING.

Here at the Wailuku Sugar Company this past season, all low-grade pans were started on fine sugar dust obtained from the Honolulu Plantation Company. One pound of fine sugar dust (taken into the footing of the molasses at proof point) was used for every 1000 cu. ft. of finished low-grade product. This sugar simply acted as a stimulant to the

saturation, making the formation of the grain more nearly simultaneous; the resultant sugar, therefore, more nearly of a size and easier purged, thereby giving us a better seed sugar for our No. 1 pans. In our work we built up one 700 cu. ft. pan, using 2 pounds of the dust, this pan then being used as the nucleus for three pans that were built from it by cutting. There was only No. 1 molasses used in the above work.

FALSE GRAIN.

This is misnamed, and should be called a subsequent grain, as from my experience it is simply a new grain that has formed at the later stage of the crystallization of the body of sugar. The common causes are too small a number of original grain, or an expansion of the massecuite due to heat, water, or an overfeed of molasses separating the already present grain to such an extent that room is allowed for this new formation to take place. Due to the incomplete time for its growth to occur and lack of material to grow on, it is distinctly smaller than the original grain and may even pass through the centrifugal screen, or if present in great multitude, be thrown by the centrifugal force against the screen holes, tending to plug the same.

PREVENTION OF SO-CALLED FALSE GRAIN.

First there must be sufficient grain formed; then careful pan work regarding the feed of molasses and water, good circulation, and good control of the pan temperature, especially in the later stages, and dropping the pan on a cooling temperature, as contraction and not expansion of the massecuite must occur.

This danger can also be to a great extent eliminated by carrying the pan to a high density at all times, particularly before dropping. An ordinary cause of false grain is this: the sugar boiler drops a pan at, say, 95 to 96 Brix, often running the washings into the same crystallizer, expanding the massecuite, giving room for the growth of the grain. This can be stopped by either cutting out the washing or by keeping the massecuite hot in a water-jacketed crystallizer for a few hours before starting to cool the massecuite.

EFFECT OF ADDING WATER TO MASSECUIE ON RESULTANT PURITY OF MOLASSES.

My experimental work this spring has led me to think that it is possible to add water to massecuite under certain conditions with beneficial results.

The conditions are these: On a heavily-boiled massecuite it is possible to add a limited amount of water slowly. While the massecuite is in motion, cooling and contracting to a certain point of saturation will not give a higher resultant molasses than when allowed to cool naturally without the addition of water to the massecuite. The saturation in my work is between 95 and 96 Brix. After the contraction of the massecuite has stopped and the minimum temperature reached for a certain point of saturation, the addition of water raises the resultant molasses purity.

REGARDING COMPLETE CRYSTALLIZATION.

Outside of the time limit at our disposal and tremendous equipment required, complete crystallization is not practical. There is a great probability of small flower grain forming between the original grains after the original grain formed in boiling has grown to a sufficient size. This occurs even while in motion, and because there is not a sufficiently rich mother liquor to develop larger crystals. These flower grain crystals in reality retard purging of the original grain and will go through screen holes used at present.

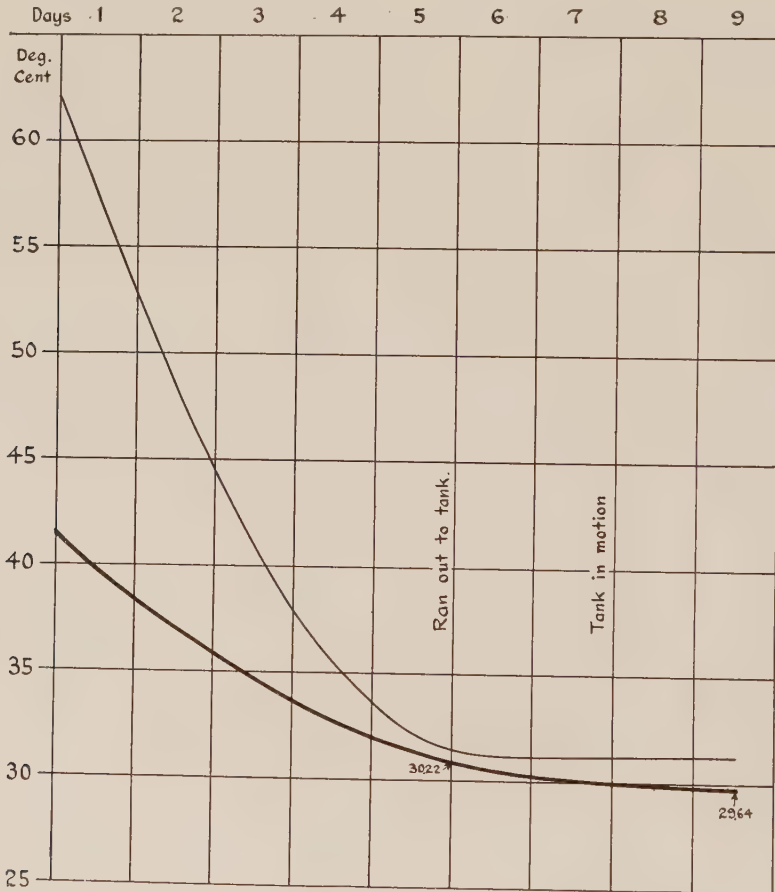
The advantage obtained by boiling to 99 Brix in place of 95 is that it exhausts the mother liquor in the pan and deposits that great portion of the sucrose on the already formed grain, leaving less inter-granular sucrose to be deposited by the contraction that takes place in cooling, cutting out the possibility of false grain and materially shortening the time of economical recovery.

In regard to the advantage of slow boiling of low-grade massecuite, it is mainly due to the better control it gives the pan man and his ability under these circumstances to keep the massecuite well together, and obliterates the dangers that arise from a too rapid feed of molasses and water. Outside of this I can find no advantage but the time element of crystallization in motion, and given two massecuites of the same final Brix purity and number of grains and same size, one taking 24 hours and the other five hours. I believe the molasses in both will finally reach the same point under the same system of temperature control in the crystallizers.

One disadvantage of slow boiling that was brought to my attention this year is the tendency of the longer-boiled pans to show a greater loss of purity in the pans. The time element in regard to low-grade molasses results was brought out rather strikingly—a record of 43 consecutive pans. During five days in the crystallizers the drop in purity of the molasses was 22 points (from 52.22 to 30.22 apparent purity); they then averaged three

days in the outside tanks in slow gravity motion, dropping to 29.64 apparent purity, showing only 0.58 of 1% gained here. It was dropped from pans (average time of boiling $9\frac{1}{2}$ hours) into hot-jacketed crystallizers. A few hours later cold water was turned on the jacket and approximately 1% of water (30° to 35° C.) was fed slowly to the massecuite while it was cooling rapidly. The temperature of the massecuite at the end of the fifth day was 30° to 32° C., or as low as my equipment would give me, at which time I believe I had reached the economical extraction point in my molasses.

The Brix of the original massecuite averaged 97.20. This ultimate drop could have been further lowered by starting with a lower initial purity massecuite. This point of purity of the massecuite and Brix are mainly dependent on the equipment at disposal, down to a certain purity, where the non-sucrose element hinders crystallization.



Massecuite.

Brix 97.20.

Pol. 96.

Purity 52.45.

Cooling water on.

Cooling water off.

Water added (approximately 1% by volume).

Composite of 43 consecutive crystallizers, June 1-25, 1920.

The three days in tank showed drop of 0.57.

(I would like to suggest that a series of experiments be undertaken to establish within reasonable bounds approximately how far down in actual operation we can carry our initial purity and still get a well-building grain within a reasonable working time on massecuite neutral to litmus.)

PURGING LOW-GRADE MASSECUITE.

During the past season at Wailuku and part of the season at Puunene, the stripping arrangements for handling low-grade massecuite were used with beneficial results, shorten-

ing the time of purging 13 to 15% at Puunene and approximately 15 to 20% at Wailuku. Apparently the main reason for these benefits was the manner of applying the heat before the massecuite went into the centrifugals and the resultant change in viscosity of the massecuite, as apparently after it had contracted to give off a low resultant molasses every degree it is expanded before centrifugalizing (if this can be done without injury to the grain) the benefit is very great. This stripping arrangement is merely a simple mechanical means of applying heat in limited quantities under satisfactory control.

Outside of the time limit at our disposal and tremendous equipment required, complete crystallization is not practical. There is a great probability of small flower grain forming between the original grains after the original grain formed in boiling has grown to a sufficient size. This occurs even while in motion and because there is not a sufficiently rich mother liquor to develop larger crystals. These flower grain crystals in reality retard purging of the original grain and will go through screen holes used at present.

**AVERAGE RESULTS OF FORTY-THREE CONSECUTIVE LOW-GRADE PANS
BOILED AT WAILUKU SUGAR COMPANY, JUNE 1ST TO
JUNE 25TH, 1920, INCLUSIVE.**

Average hours boiling	9.5
Average temperature of pan, degrees Fahr.	147.5
Average vacuum	26.8
Average Brix into crystallizers — 97.20 out of cryst.....	95.91
Average polarization into crystallizers— 50.98 out of cryst.....	50.08
Average purity (a) crystallizers — 52.45 out of cryst.....	52.22
Average purity (a) hot from massecuite after boiling.....	40.50
Average purity (a) cold at end of 5.7 days going out to tanks.....	30.22
Average purity (a) cold at end of 9.0 days coming into house.....	29.65
Massecuite in slow motion from tank to tank.	
Drop in purity of molasses, 5.7 days.....	22.00
Drop in purity of molasses, 9.0 days.....	22.58

The crystallizers used in above work were the circular water-jacketed type. Hot water was on the jacket at the time of dropping pan to keep out false grain forming, which it did. A few hours after dropping pan, cold water was turned on the jacket and the temperature of crystallized massecuite was forced down as rapidly as possible. The above results show the great benefit of the water-jacketed type of crystallizers over the tank system, and that the cooling factor, to arrive at a commercial exhaustion of the molasses, is indispensable when a boiling house is limited by time in its complete cycle of manufacture.

From Mr. F. H. Hadfield, Hilo Sugar Co.:

CLARIFICATION.

We try to keep our juice running through the heaters at about boiling point, as too high a temperature tends to form salts of organic acids, which are dark colored and easily decomposed, forming acid substances which eventually cause inversion. Too low a temperature gives an imperfect, cloudy clarification and with lime does not precipitate the gummy matters, causing suspended matters in the first cells and scale in the last cells of the evaporators.

EVAPORATORS.

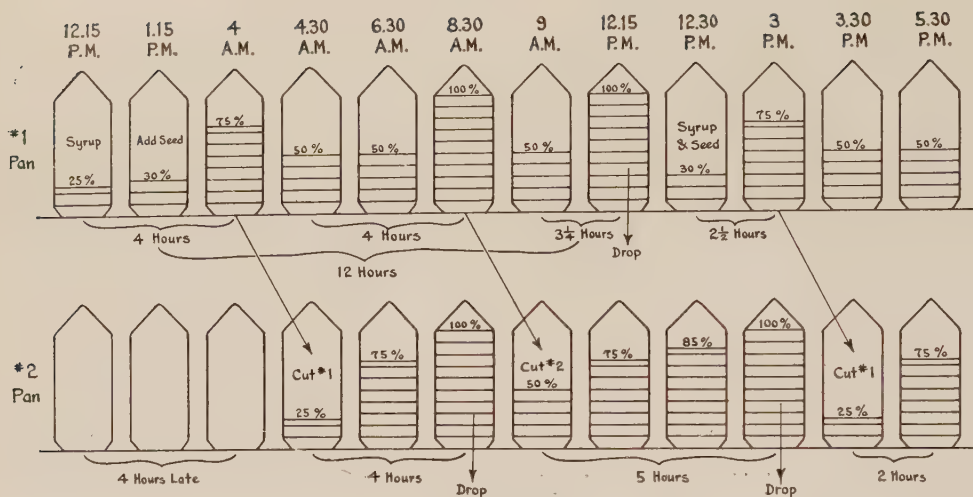
All cells are boiled from four to six hours under atmospheric pressure. In the last cell we use caustic soda, and in the others muriatic acid, as the caustic soda loosens the scale and the acid dissolves any suspended matters deposited through imperfect clarification. Though incrustation in evaporator tubes is unavoidable, it is our endeavor to carry as near neutral a juice as possible, thus decreasing the natural tendencies of either an acid or an alkaline juice of dissolving lime salts and causing scale in the evaporators.

BOILING.

General Methods, No. 1 Massecuite.

Begin No. 1 pan with syrup and boil to string-proof about 25% of pan, then take in seed, building up to 75%. First cut down to 50% of pan, building up to 100%; second, cut down to 50% of pan, building up to 100%, finishing off with molasses and dropping, taking 12 hours.

Begin No. 2 pan by taking first cut from No. 1 pan of 25%; build up to 100%; finish off with molasses and drop. Then take in second cut of 50% from No. 1 pan, finishing off with molasses, and drop.



Sugar boiling at Hilo Sugar Company.

The above is just a rough idea of time and per cent in pans and the nearest approach we have of arriving at an even grain in our No. 1 sugar.

General Methods, No. 2 Massecuite.

Take in 25% syrup of 86-87 purity and molasses of 50 purity, and boil to grain, adding about 5 pounds of carbonate of soda. Build up slowly till 90% of pan, and drop at about 95-96 Brix.

FALSE GRAIN—CAUSES AND PREVENTION.

1. Sudden agitation of magma.
2. If the mother liquid in which the crystals float becomes as high in purity as it was before graining.
3. Forcing circulation at the latter part of the boiling.
4. Charging pan with syrup or molasses of a lower temperature than the massecuite in the pan.
5. Keep the massecuite lower in vacuum during boiling than at the beginning of strike.
6. Steam the molasses before taking into the pan, dissolving any small grain that may be there.

CRYSTALLIZATION.

1. Experiments lead us to conclude that complete crystallization may take about 8 days.
2. A warm temperature is more conducive. Water-jacketed crystallizers would be preferred, as they continue the process of boiling in the pan both with regard to temperature and circulation.
3. The adding of water is unsuccessful, the purity always increasing.
4. It is possible to add water, however, without raising the purity, provided the crystals have been boiled hard, but the process requires skilled attention both during the night and day.
5. Boiling to 99° Brix and diluting with water is advantageous. I have always preferred waste molasses as a dilutant rather than water, as an even temperature is easily kept and requires little attention.
6. It is mixed by a scroll just before entering the mixer.
7. Long and slow boiling gives, usually, hard and large grain, with a well-exhausted final molasses.
8. The massecuite boiled for 24 hours will give a much lower final molasses than when boiled for five hours.

Taking up the individual topics suggested:

CLARIFICATION.

Three places which have tried heating juices to a lower temperature report that the clarification is not as good as at 212°. None of the others commented

on this point. Our experience this year has been that just as clear juices can be obtained at 180° as at 212° , but that as a rule a considerably longer time of settling is required at the lower temperature. We ran through the first four or five weeks at 180° , but as the season advanced and the mill speeded up we had to increase our temperature to 190° , 200° , and finally 210° , always dropping down Saturday night to 180° . We are putting in an additional settling tank for the coming season, which should let us work at a lower temperature again. It may be, too, that the slower settling and greater capacity required at 180° will offset the advantage of less deterioration at this temperature. Our results on juice deterioration this year have been referred to the special committee on this topic.

EVAPORATION.

Nothing new has been reported under this heading. When the representatives of Crockett Refinery were down here last year, mention was made of a chemical method of cleaning scale from evaporator tubes, using very strong carbonate of soda, followed by muriatic acid. Their method in detail is as follows:

PROCEDURE OF BOILING OUT EVAPORATORS.

(As practiced by California and Hawaiian Sugar Refining Co., Crockett, Cal.)

After all sweetwater is rinsed out of the evaporators, sufficient 20% soda ash solution is pumped into them to just cover the tubes. This is then boiled continuously for 14 hours, making up the loss by evaporation with fresh water. A vacuum of about 10 to 15 inches is maintained in the first body and about 24 inches in the last, no special note being taken of the temperature.

After the fourteen hours the soda is run back to the soda tanks and the bodies are rinsed out, the rinsings also being run to the soda tanks. After rinsing, the evaporators are filled with water to the height of the tubes and boiled for 30 minutes. This removes any soda that has penetrated the scale and makes for economy of acid. This water is run to the sewer, the bodies being again rinsed.

The bodies are then filled with water and sufficient muriatic acid is drawn into the bodies to produce an acidity of 0.3% HCl. This acidity is maintained throughout the boiling period, by fresh additions of acid if necessary. The acid boiling lasts four hours, after which the evaporators are thoroughly washed out. They are generally found to be quite clean after this treatment.

It is a little hard to estimate the quantity of soda actually consumed in this operation. There is some chemical loss, which is probably small. There is also an entrainment loss which can be kept small, but must be watched, as the soda solution foams considerably. Finally there is a mechanical loss in the soda that is washed to the sewer. The sum of these should not exceed 4% of the total used, but will often run much higher if not carefully watched.

The amount of acid required varies with the different bodies, in our case from about 2 carboys (117 pounds each) in the first body to about 12 carboys in the last. The total for the five bodies, each holding about 2000 gallons of water, averages about 30 carboys.

The evaporators at Crockett are of the Wellner Jellinek type, each cell containing 3027 sq. ft. heating surface and requiring about 2200 gallons of liquid to cover the tubes. The chief drawback to the use of this process in Hawaii lies in the amount of soda ash and acid required. Our Standard evaporators as a rule have a much larger ratio of volume to heating surface and would need proportionately more liquid to cover the tubes. 0.3% HCl means about 1 gallon of commercial muriatic acid per hundred gallons of water to start with. This strength of boiling acid attacks iron perceptibly, and a much weaker acidity will not dissolve the scale. At Crockett thus far they have not been able to detect any harmful effects from the acid used, and there has resulted a large saving in labor over the old method of boiling with soda and scraping.

We tried this method at Pioneer during the last month of the grinding season, using about a 15% soda ash solution and in the subsequent acid boiling adding acid to maintain a decided acid reaction to litmus, without trying to control by titration. While the tubes of the Lillies were not perfectly cleaned, the evaporators seemed to work as well as when scraped by hand, and we saved a good deal of labor at the high bonus rate then prevailing. A very important part of the procedure is a thorough boiling out with water between the soda and the acid treatment; a mere rinsing leaves a large amount of soda adhering to the scale.

I have made a good many experiments lately on small sections of scaled tubes, hoping to improve on this process, but without entire success, though the indications are that, with the kind of scale we have here, caustic soda is much more efficient than the carbonate. It removes more scale by itself and requires less acid in the subsequent treatment. As Mr. Donald points out, a very strong caustic soda solution will eventually remove all scale without any acid treatment. I have cleaned small sections of fourth body tubes fairly well by boiling for half an hour in a 50% by weight solution of caustic soda. The cost of such a solution in sufficient volume to cover all our tubes would perhaps be too great, though possibly by working at a very low level it might be made profitable. Another scheme which seems possible is to spray the tubes with a little 50% soda solution, then turn on steam in the calandria, thus concentrating the adhering soda in place. A method which has worked very well on a small scale and which we intend to try out next season, is to boil for about an hour at atmospheric pressure with ten per cent caustic soda, drain off soda to a storage tank, and, without rinsing, turn on steam in the calandria for half an hour. This concentrates the soda left in the scale and cracks off most of the scale, so that the amount of acid required for the final cleaning should be much lessened, provided a thorough boiling with water is given before the acid treatment.

BOILING—GENERAL METHODS.

The proposal of a standard method for sugar boiling did not arouse as many objections as I had hoped. The choice of methods appears to be narrowed down to two: (1) the method proposed and (2) the one in more general use in Hawaii, where only one purity of first massecuite is made, taking back sufficient molasses into each strike to lower its purity to about 76 to 78. According to published reports this latter method is no longer used to any great extent in any other cane sugar country. It has the advantage of apparent simplicity, as only one grade of first massecuite is made, and of uniformity for the same reason. On the other hand, more molasses is kept in circulation, and since the average purity of the first massecuite is lower than where it is reduced in three stages, the average yield of sugar per strike is lower, which necessarily means more strikes, more pan capacity and more steam for a given weight of sugar produced.

The objection to the first method is that three grades of sugar are made. The average variation in this respect is shown by the following figures from Pioneer:

AVERAGE ANALYSES WHILE MAKING 96° SUGAR, DECEMBER 20, 1919,
TO JANUARY 19, 1920.

Purity syrup: average daily, 85.9; highest, 87.8; lowest, 82.7. Remelt, 75.9. Cuts from Pan 2, Brix 87.3, purity 85.3.

	Massecuite			
	Brix	Purity	Pol. Sugar	Purity Molasses
1a	93.0	86.1	97.5	66.0
1b	94.6	78.7	95.1	56.2
1c	95.6	74.5	94.8	52.0

AVERAGE ANALYSES WHILE MAKING 97° SUGAR, JANUARY 19, 1920,
TO APRIL 19, 1920.

Seed, 76.5; remelt, 74.0. Syrup: average, 87.1; high, 89.3; low, 84.9. Cuts from Pan 2, 86.0.

	Massecuite			
	Brix	Purity	Pol. Sugar	Purity Molasses
1a	93.4	85.9	97.6	66.8
1b	94.8	78.9	96.9	57.4
1c	95.7	74.7	96.1	53.5

The variation in polarization is greatest when making 96° sugars. It can easily be "smoothed out" if necessary by "painting" the 1a strikes with 1c molasses to reduce their polarization, and washing up the 1c strikes correspondingly, as was done here in 1919 and in 1920 for part of the season. An average of 32 strikes shows the change effected:

	Massecuite			
	Brix	Purity	Pol. Sugar	Purity Molasses
1a	93.5	85.0	96.8	65.6
1b	94.7	77.7	95.7	56.5
1c	95.6	74.1	95.4	53.3

This point was discussed with the technical men from Crockett, who said they had no objections to the method from a refinery standpoint, as the grain was the same in each strike, and they could see no particular use in reducing the variation as done in the last example. The old objection to mixed sugars was on account of difference in grain, where small-grained sugars made from molasses were washed up to polarization and mixed with larger-grained first sugars.

Another objection to Method 1 suggested by Mr. Donald is the necessity for separate storage tanks for the different grades of molasses. In the modification

used here this objection is done away with, as all the molasses from 1A is taken back into 1B, all from 1B is taken into 1C, and all from 1C is boiled for the crystallizers, so the only storage required is one set of tanks for the molasses from a 1A or 1B strike and another for that which is to be boiled for low grade. It was partially for this reason that the modification was made. No molasses is left over waiting for the proper strike to fit into, and none is taken back into the 1A strikes.

Mr. Fries, who, I believe, introduced the 3-massecuite method at Lahaina, objects to the modification of taking back all the molasses on the ground that with low-purity juices the 1c molasses may result too low for good low-grade work. We get around this difficulty by omitting the 1c strike altogether in such a case. An arbitrary limit of, say, 55 purity is set. If the 1B molasses turns out 56 it is reboiled in the next (1c) strike and there reduced to about 51 or 52. If the 1B molasses runs lower than 55 it goes to the low-grade pan without further boiling and the next No. 1 strike is made from straight syrup. I do not know that there is much choice between the two methods, but the modification seemed a little simpler in that it avoided all calculations or tables and that no first molasses was kept in circulation. Theoretically it seems better to have a constant purity molasses for low-grade boiling, but a difference of four or five points did not seem to make much difference in our results, as long as the minimum was not below 50.

Von Stietz* describes a method used in a Java factory where three boilings at 85-90, 80, and 70 purity for first massecuite and one at 60 purity for second massecuite were made. This is very similar to our Method 1. It was subsequently discarded because too much molasses was kept in circulation! The method finally adopted was as follows:

Strike No. 1, made from syrup of from 85 to 90 purity, yielding raw sugar of 98.4 to 98.8 polarization and molasses of 70-75 purity.

Strike No. 2, grained from No. 1 molasses and built up on same, yielding a No. 2 sugar which is used for seed in the No. 1 strikes and a molasses of 45-50 purity.

Strike No. 3, made from a cut of No. 2 and built up with 45-50 purity molasses to a massecuite of 60 purity for the crystallizer, yielding a low-grade sugar which is remelted, and a final molasses.

A somewhat similar method was, I think, used at one time at Ewa.

Were we permitted to make a 98 polarization sugar I would consider such a method the ideal one, as it minimizes the amount of molasses returned and, graining in a purer medium, furnishes a better and larger seed grain for the No. 1 sugars, but it would not be advisable to consider this method under existing conditions in Hawaii on account of the difficulty in keeping the sugar down to 97 polarization.

BOILING—LOW GRADE.

The feature of the year is the very general adoption of the use of powdered sugar for forming grain. Those who have tried it out almost without excep-

* Louisiana Planter, 1920, p. 92.

tion are in favor of it. The method is used at Crockett Refinery for graining all their white sugar as well as their low-grade strikes. About a quart of powdered sugar is used for a 1700 cu. ft. strike. They do not consider that the sugar introduced is really the grain on which the strike is built, but believe the sudden shock, together with the spreading of a few crystals through an already super-saturated solution, causes crystallization to take place. The amount of sugar taken in for shock seeding or the size of grain used does not make much difference, the important point being the density of the syrup at the time it is seeded.

At the Spreckels beet sugar factory they have worked out a very rapid method for graining first sugars. A small single-effect evaporator furnishing vapor to the heaters concentrates a portion of the syrup to about 80 Brix. This is kept in separate storage tanks. When a pan is started up they draw in a charge of this practically saturated syrup, turn on the steam, give it a shot of white sugar and go on boiling; the grain appears immediately.

We have been trying the powdered sugar graining method at Pioneer off and on during the past season, the majority of our low-grade strikes being thus grained. Our sugar boilers are not enthusiastic over it, and are not at all sure that the grain comes any quicker or evenner with than without its use. We originally used C. & H. powdered sugar, made up of irregular crystals varying from 0.01 to 0.10 mm. in diameter, averaging about 0.05. Our finished No. 2 massecuite averages about 0.3 mm. diameter of crystals and a total weight of about 10 tons crystals. If the powdered sugar alone supplied the seed for one strike, the crystals would have to grow to only six times their original diameter or 216 times their original weight, so the weight required for seeding would be $\frac{20,000}{216}$

= 92 pounds per strike. We next tried some sugar dust, which has a very much finer grain, averaging possibly 0.01 mm. in diameter. Theoretically, less than a pound of this should furnish enough grain for a strike. Results from this were no better and no worse than with the coarser-grained sugar.

A possible explanation of our inability to detect any improvement from the use of powdered sugar is that we have already been "shock seeding" without knowing it. The majority of our strikes are grained by boiling to proof and dropping into an insulated tank. As there is always a good deal of old grain left in the bottom of the tank, this, together with the agitation brought about by dropping, may in itself be enough to induce crystallization. On the other hand, many of our strikes were grained in the pan, with and without powdered sugar, and we have never been able to detect any consistent difference in results. We grain by boiling to proof and letting stand. Grain first appears in about half an hour, but takes about two hours standing to grow big enough to start boiling. The amount of grain produced varies with the Brix, purity and *stickiness* of the boiled-down molasses, and the variations from these causes are greater than from the presence or absence of powdered sugar.

We expect to continue its use next season and may know more about it after another year's trial.

FALSE GRAIN.

Most of us are apt to blame the crystallizers for false grain in low-grade massecuites. Last year, in an attempt to remedy this evil, we insulated and covered the two crystallizers nearest the pan, dropping molasses strikes directly into these alternately and pumping the massecuite out and into the ordinary crystallizers after 12 to 24 hours. The insulation was fairly efficient; massecuite dropped in temperature only four or five degrees Centigrade in the first 24 hours, against ten to twelve degrees in the open crystallizers. Considerable crystallization took place during this time, as is shown by the average of 24 strikes:

	Brix.	Purity.
Massecuite	97.0	53.9
Molasses, separated at once	95.3	44.8
Molasses, separated after 14 hours	95.3	40.5

The grain was quite regular, and practically no very small grain was seen in any of the strikes. The molasses was rather more viscous than usual and harder to separate in spite of the good grain. This was while we were running the mill slowly. As the mill speeded up and we had less time for boiling, the grain got worse and soon it was no better than in previous years. We then tried running every other strike direct to the regular crystallizers. For several weeks we examined almost every strike with a microscope, but were unable to detect any difference in size or appearance of grain between massecuites which had cooled directly in open crystallizer and those that had been kept warm for half a day. A record is kept of the drying time and the apparent purity of molasses from each crystallizer. The average time of drying (700 cu. ft. massecuite dried in twenty-four 30" and two 40" machines), and the average apparent purity of molasses from the "insulated" and the "direct" massecuites is given below. During part of this time we were using steam outside the centrifugal baskets to help drying. Massecuites dried cold and those dried with steam are averaged separately.

	Steam		No Steam	
	Insulated	Direct	Insulated	Direct
Number of crystallizers ...	19	14	8	11
Hours per crystallizer ...	11.26	11.36	23.81	20.70
Purity molasses	34.96	34.35	32.16	32.07

As there was no benefit shown by the insulated crystallizers we stopped using them. We have made a large number of microscopic examinations of low-grade massecuites, following them up from day to day, and never, when the ordinary method of boiling was used, have we noticed small grain appear which was not present when the crystallizer was first filled.

In an attempt to find out the influence of rapid cooling we took samples of massecuite from the flume at the time of dropping a strike and from the still warm

crystallizer at 24-hour intervals, put them in mason jars tied to the large gear outside of the crystallizer, thus cooling them down to factory temperature in a few hours, and compared them under the microscope with the massecuite cooling normally in the crystallizer. The sample taken on first dropping the strike developed a large number of new crystals of about 0.01 mm. diameter. Samples taken from the crystallizer after 24 hours or more showed no traces of this small grain. We still have these samples, and even after several months' standing no difference can be seen between those cooled rapidly after 24 hours and one taken from the crystallizer after 13 days. We did not carry the experiment further to determine the exact time limit of safety before rapid cooling, but have proved that with our massecuites at least it is less than 24 hours.

Mr. Pitcairn has further demonstrated this at Wailuku. By turning cold water on his jacketed crystallizers after the first day he has been able to cool down to 30° C. in four to five days, saving considerable time in crystallization. (Our 700 cu. ft. open crystallizers take from 6 to 9 days to cool down to 30°.) His results show that the drop in purity of molasses follows the temperature line very closely, and he has not been troubled with any false grain due to faster cooling.

After a heavy massecuite has been dropped, the flume, unless scraped clean, will continue to drain slowly for 24 hours or more. An examination of these drippings shows them to be full of fine grain. Of course, their proportion to the total massecuite is very small. The remedy is obvious, but not always easy to apply.

Mr. Orth's scheme of adding a few gallons of water to a crystallizer just before filling is novel and worth trying.

SIZE OF GRAIN.

If the percentage of grain less than 0.1 mm. long is kept low we have not found an irregular grain to be a disadvantage in drying. I believe a massecuite made up of half 0.2 mm. and half 0.5 mm. grains will dry better than one all 0.2 mm. Towards the end of the season we tried to emulate our Cuban friends and boiled one large-grained strike on a cut from No. 1 massecuite. The cut was 74.9 purity, the molasses boiled in 55, and the finished strike 96.0 Brix and 60.9 purity. In spite of careful work and slow (12½ hours) boiling, false grain came in at different stages, mostly toward the end. The finished strike consisted of the original grain, 1.5 to 0.8 mm. long, secondary grain which had come in early and grown to 0.2 to 0.4 mm., and a large amount of "false" grain ranging from 0.01 to 0.05 mm. The boys found it almost impossible to "separate" this massecuite, as the fine grain plugged up the screen of the separator. I predicted that it either would not dry at all or might partially dry with a layer of molasses on the outside.

After a week we tried four buckets full in a 30" machine. To the surprise of everyone it dried fairly well in 15 minutes and perfectly in 30 minutes, yielding a far better sugar than we ever get from our low-grade massecuites. The molasses run-off contained considerable fine grain and had an apparent purity of 32, which is lower than our average.

An examination of the dried sugar under a low-power microscope solved the mystery of why false grain didn't prevent a good drying. Adhering to the surface of nearly every large crystal were seen numerous very small ones. The

large grain had acted as an aid to filtration by increasing the "screening area." It was apparent that had the grain been made more even by removing the very large crystals, drying would have been much more difficult.

It is barely possible that by following up this idea an improvement in our low-grade work might be developed. The trouble with our present method is that to get crystal surface enough for the proper exhaustion of low-grade massecuites they have to be made of very small grain. This means a slow-drying massecuite, a comparatively low polarizing second sugar and more adhering molasses which is necessarily returned to process. Could a mixed grain be developed in some way, which would have sufficient small grain for good crystallization and sufficient large for better drying?

EXPERIMENTAL STRIKES.

On the few occasions last year when the boiling house was not working to full capacity we tried some experimental strikes, boiling by entirely unorthodox methods just to see what would happen. Most of them turned out unsatisfactorily, but they may be worth recording if for nothing more than to save someone else the trouble of doing the same thing.

No. 438-8. Thirteen tons molasses of 54.8 purity boiled blank in 45 minutes, about a quart of powdered sugar added and dropped to a crystallizer. Grain appeared in 1½ hours, and in two hours was a very good square grain from 0.05 to 0.10 mm. long. At this time a second blank strike consisting of 22 tons molasses of 50.7 purity boiled in 1 hour 10 minutes was dropped on top of the first. Seven hours after dropping the second portion, the original grain had grown to 0.10 to 0.15 mm., but a large number of secondary grains of 0.05 mm. had come in. Ten hours later the grain had not grown any more, the mass foamed up badly, and the temperature rose to 66° C. An ordinary strike would have been about 57° C. at this stage. The mixed strike was 97.8 Brix and 52.1 purity. After standing 39 days it dried fairly well (on dilution) and gave a molasses of 90.6 Brix and 32.9 apparent purity.

No. 583-17. Grain made similar to the above, from 2 tons remelt and 12 tons 51.4 purity molasses boiled blank and dropped to a crystallizer. Eight hours later a second lot of 24 tons 51.0 molasses dropped on this. Complete strike was 99 Brix and 51.0 purity. The original grain finally grew to about 0.2 mm., but a large amount of small grain of 0.02 to 0.05 mm. also appeared. This strike was very hard to dry.

No. 584-2. Twenty-five tons of 51.4 purity molasses were boiled blank in 1 hour 15 minutes and dropped into a crystallizer containing about 10 tons of old massecuite. Much false grain appeared. This is about the worst I have seen.

No. 582-16. Grain was made in the pan from 12 tons 52.8 purity molasses. After grain stood in the pan for 6 hours, 22 tons No. 2 molasses of 35.5 purity were boiled slowly, taking 7 hours to boil. Finished strike was 99 Brix, 40.7 purity, with fairly good grain from 0.1 to 0.3 mm.; very little smaller.

No. 579-3. Twenty-five tons No. 2 molasses of 85.8 Brix and 33.4 purity were boiled blank to 100.2 Brix in 1 hour 40 minutes and dropped into a crystallizer containing about 11 tons of 33 days old massecuite of 96.6 Brix and 55.8 purity. This molasses was boiled so heavy it took 5 hours to discharge from the pan. Mixed strike was 98.4 Brix and 39.1 purity. No secondary grain appeared in this strike. Purity of separated molasses after 2 days was 30.7; in 4 days it had cooled to 36° C. and the separated molasses was 29.7 purity; after 9 days, purity was 27.4; 18 days, 25.9; 31 days, 24.9; 37 days, 24.7; 79 days, 24.6. This is the most promising experiment tried yet; the grain is uniform and fairly large—about 0.4 mm. Given sufficient pan, cooling and centrifugal capacity it might pay to go after a lower purity final molasses by working it in two boilings instead of one. We intend to experiment further along this line.

No. 586-4. The first experiment of boiling "waste" molasses blank turned out so well that we tried one more, with the idea of making it crystallize out on a much larger grain. Thirty tons of molasses of 83.4 Brix and 37.4 purity were boiled to 99 Brix in 2 hours 45 min. and dropped into an empty crystallizer, taking 3½ hours to discharge. Two tons of dry No. 1 sugar were added as the crystallizer filled. No secondary grain appeared at first, but after 24 hours it came in large amount. After three months in the crystallizer the grain has grown very little, the majority being 0.02 to 0.1 mm. Evidently not enough "seed" was used to take up the sugar crystallizing from a 37.5 apparent

purity molasses. Somewhere between the conditions of the last two experiments there may exist a happy medium with enough crystal surface to take up all the sugar that will come out, and still be large grained enough to yield a well-dried sugar.

TIME FOR COMPLETE CRYSTALLIZATION.

This seems to vary in different factories. Tests made at Onomea and at Hilo Sugar Co. indicate that crystallization is practically finished in from four to eight days. At Pioneer we have held over a number of crystallizers and made separations at regular intervals as we did last year, and invariably find a drop in purity of molasses of from one to two points between the fourteenth and the twenty-eighth day. After the first month the drop is very slight, probably less than one point on standing four months longer. The massecuite itself does not drop in purity during one month; we have not yet checked it up for longer periods.

Probably the nature of the impurities in the molasses has a great deal to do with the duration of crystallization. Molasses from around Hilo is generally considered to be easier to reduce to a low purity than that from other places; if the crystallization takes place easier, it is logical to suppose that it will be completed sooner. Another reason for the difference may be that some factories do more of their crystallization in the pan than do others. Due to our small low-grade pan capacity, many of our strikes have to be boiled in less than six hours. The average of 88 separations on hot massecuite leaving the pan last year at Pioneer was:

	Brix.	Apparent Purity.
Massecuite	97.0	54.0
Molasses	95.7	44.3

Some factories are able by long boiling to get the mother liquor in a low-grade strike down to less than 40 apparent purity, which would tend to shorten the time for after-crystallization.

EFFECT OF ADDING WATER.

We have never been able to add water to a low-grade massecuite (and we have tried every known method), without raising the ultimate purity of its molasses. Unless we accept the now disproven theory that a concentration to a higher than the usual factor Brix does not cause more sugar to crystallize out, it is obvious that reducing this Brix in any way must dissolve sugar. We have, indeed, added water in small amounts to a massecuite which was still cooling, and obtained a continued *drop* in molasses purity, but similar massecuites without the water dropped still lower.

Experimental work on a small scale indicates that it is possible to separate the molasses from a highly-concentrated massecuite, add a small amount of water to it, mix with sugar and separate again with very little if any increase in purity. This can be explained only on the ground that the molasses first separated is still in a supersaturated condition. It may be that a certain degree of supersaturation is necessary to force crystallization and that a very heavily concentrated molasses never reaches the point of exact saturation. Such a condition suggests that it might be possible to mix a little water with a massecuite in such a way that some of it at least would be used up in reducing the supersatura-

tion of the molasses and would not dissolve sugar. Our experiments along this line lead me to believe that if a massecuite is to be dried at 95 Brix there probably is a practical advantage in boiling to a higher Brix and diluting to 95, but that the gain is in time only. If two similar massecuites, one of 95, the other of 98 Brix, were crystallized for six months, then the 98 reduced to 95 with water, the molasses purities from each should be the same. Similarly, a prolonged boiling undoubtedly shortens the period required for practical crystallization, though ultimately two massecuites of the same Brix and composition must yield exactly the same purity molasses.

Mr. B. B. Henderson made some very careful tests on the rise in purity caused by adding water in our crystallizers. Water was added in varying amounts, taking from 6 to 24 hours to add one barrel to a 700 cu. ft. crystallizer. A summary of his results is:

% water	2.6	2.5	2.2	1.8	1.6
Original purity of separated molasses.....	29.5	30.1	31.6	30.5	32.0
Purity after adding water	32.5	31.8	33.0	32.4	33.1
Increase in purity	3.0	1.7	1.4	1.9	1.1
Increase for each per cent water added.....	1.15	0.68	0.64	1.06	0.69
Hours in crystallizer after adding water before separating	6	12	6	48	42

He concludes that, very roughly, one per cent of water increases the molasses purity by one point.

VISCOSITY OF MOLASSES.

Mr. Henderson also made a large number of tests on the viscosity of molasses, and the effect of varying the Brix and the temperature.

He made use of the falling sphere method, using the length of time taken by a steel ball to fall through a definite depth of molasses as a measure of viscosity. The method was found very difficult to manipulate so as to get concordant results, but averaging a number of tests he reports that, working with a molasses of 93.6 Brix and 32.4 apparent purity, within the limits of 27° and 43° C., heating a molasses 4° reduces its viscosity to about the same extent as adding 1% of water. One per cent of water on the molasses in a massecuite is equivalent to about 0.7% water on the massecuite.

The average of a good many tests here has shown us that heating a massecuite 5° C. raises the purity of molasses about 1 point. Heating it 4° would raise the purity of the molasses 0.8, while adding 0.7% water would raise it 0.7 point, so from this calculation there is very little choice between water and heat, either as regards their benefits or their harm.

As stated, these are all very rough calculations, and should only be regarded as a first attempt to reduce to figures what has previously been left largely to guesswork. It is evident that a great deal more data from different factories will be needed before we really can know much about the subject.

LABORATORY ACCOUNTING.

Mr. Foster has sent in a set of the card forms he uses for routine reports and control.

Mr. Elliot sends a blank form and the method used at Hakalau for calculating solids and sucrose balances.

MILL REPORT
HAKALAU PLANTATION CO.
TOTAL SOLIDS and TRUE SUCROSE BALANCE

For theweeks ending.....19.....

Tons of Mixed Juice, gross weight

Tons of Dry Press Cake

*Brix of Mixed Juice

*Brix of Theoretical Clarified Juice

% Precipitated Soluble Solids

Tons Precipitated Soluble Solids

Gross Wt. M. J.tons X% Precipitated Solids =

Tons Lime Used

Tons Soluble Solids in Press Cake Juice

Tons Total Soluble Solids in Press Cake

Tons Dry Press Cake

Tons Total Soluble Solids in Press Cake

Tons Insoluble Solids in Press Cake

Tons of Mixed Juice, gross weight

Tons of Insoluble Solids in Press Cake

Tons of Mixed Juice, net weight

TOTAL SOLIDS BALANCE

Net Weight of Mixed Juice

Brix of Mixed Juice

Tons Soluble Solids in Mixed Juice

Tons Lime Added

Total Tons Soluble Solids in Mixed Juice

Tons Soluble Solids in Press Cake

Tons Soluble Solids in Sugar

Tons Soluble Solids in Molasses

Tons Soluble Solids in Undetermined Loss

TOTAL

•	%
•	%
•	%
•	%
•	%
100.00	%

TOTAL SUCROSE BALANCE

Net Weight of Mixed Juice

True Sucrose % Mixed Juice

Total Tons True Sucrose in Mixed Juice

Tons True Sucrose in Press Cake

Tons True Sucrose in Sugar

Tons True Sucrose in Molasses

Tons True Sucrose in Undetermined Loss

TOTAL

Purity of Undetermined Loss

•	%
•	%
•	%
•	%
•	%
100.00	%

We are using a form of Sugar Boilers Record which is rather convenient for checking up individual strikes. They are made up of cheap paper, 100 perforated white sheets and 100 yellow sheets alternating in a book. The yellow sheets are carbon copies, retained on the pan floor; the white sheets are torn out and filed in the laboratory.

We tried out a new system of reporting on individual fields, last year, which has some good points. A sample page of the Field Book and a blank form for Distribution of Sugar to Fields are appended. We have found in the past that the actual sugar per cent cane produced comes very close to the calculated

PIONEER MILL COMPANY SUGAR BOILER'S RECORD

Pan No.

Strike No.

Crystallizer No. 19.....

Started graining.....m. Finished graining.....m. Time.....h.....m.

Started boiling.....m. Finished boiling.....m. Time.....h.....m.

Finished discharging.....m. Time.....h.....m.

Total.....h.....m.

Made from.....of massecuite ofBrixPol.Purity.

Made from.....of syrup ofBrixPol.Purity.

Made from.....of seed ofBrixPol.Purity.

Made from.....of remelt ofBrixPol.Purity.

Made from.....of molasses ofBrixPol.Purity.

Remarks :

.....

.....

.....
Sugar Boiler.

Started drying.....m. Finished drying.....m. Time.....h.....m.

Massecuite ofBrixPol.Purity.

Sugar ofBrixPol.Purity.

Molasses ofBrixPol.Purity.

..... 19.....

FIELD

Commenced

Finished

			TONS CANE	PER ACRE	TONS SUGAR	PER ACRE	Tons Cane Per Ton Sugar 96°
.....	Acres Plant						
.....	" Ratoon	Yield					
.....	" Total	Estimate					

DATE	CANE TONS	MILL JUICE			CANE		BAGASSE		Q.R.	TONS SUGAR
		Brix	Pol.	Purity	% Fiber	Pol.	Pol.	% Moist		

MILL REPORT PIONEER MILL COMPANY Distribution of Sugar to Fields

For the 4 weeks Ending May 29th 1920 Crop 1920

Fields	Tons Cane	Q. R.	Tons Sugar Calculated	Adjustment	Tons Sugar Actual
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"Quality Ratio," and have made use of this in calculating field yields, going direct from "Quality Ratio" calculated from crusher juice to tons sugar calculated due a field without any intermediate steps. Stock is taken in the factory on the last Sunday in each month and the sugar made and in process reported for the period on the usual forms. The tons cane and average quality ratio of each field ground during the period are entered on the distribution sheet, the total tons calculated sugar from all fields added up, and across from it is set down the total sugar actually made. The difference is the total adjustment, which is apportioned rapidly to each field according to its proportion of total calculated sugar. The sum of the individual figures under "Adjustment" and "Tons Sugar Actual" must check up with the totals, previously entered.

The method does not take into account the influence of variation in fiber in different fields on extraction, but where 15 or 20 different fields are ground in the same day this is impossible to do with accuracy anyway.

At the end of each month all fields finished during that month can be reported on finally. No further adjustment is required at the end of the year.

Ammonium Nitrate, a New High-grade Fertilizer.

Ammonium nitrate is attracting a good deal of attention just now as one of the promising nitrate fertilizers. This compound had been made in Norway, where electric power was fairly inexpensive, for a number of years before the war started. One of the most modern plants is illustrated here, and shows the scale upon which the industry is conducted.

With the beginning of the world war the demand for nitrates for the manufacture of munitions increased enormously. At the same time, the shipment of sodium nitrate from Chile was greatly interrupted by the submarine campaign and the shortage of ocean tonnage. The manufacture of ammonium nitrate was taken up by all the warring countries, and now that the war demand has ceased, agriculture can benefit by the valuable supply of high grade fertilizer.

Several processes for the manufacture of ammonium nitrate were brought to a high state of efficiency both by the Allies and the Germans. Under ordinary conditions the nitrogen of the atmosphere is absolutely useless for animals and all plants except the legumes. In the electric arc, under a high pressure, it can be made to combine with hydrogen to form ammonia. Part of the ammonia formed can be easily oxidized to nitric acid and this acid unites with ammonia to form a neutral salt, ammonium nitrate. Thus the nitrogen in the two more or less troublesome liquids is changed into a safe, convenient salt. This salt has the great advantage that it is very concentrated and so is extremely economical to ship. It contains about thirty-four per cent of nitrogen which is equally divided between ammonia nitrogen and nitrate nitrogen. Compared with this high nitrate content, ammonium sulfate contains about twenty and a half per cent of nitrogen, and sodium nitrate about fifteen and a half per cent.



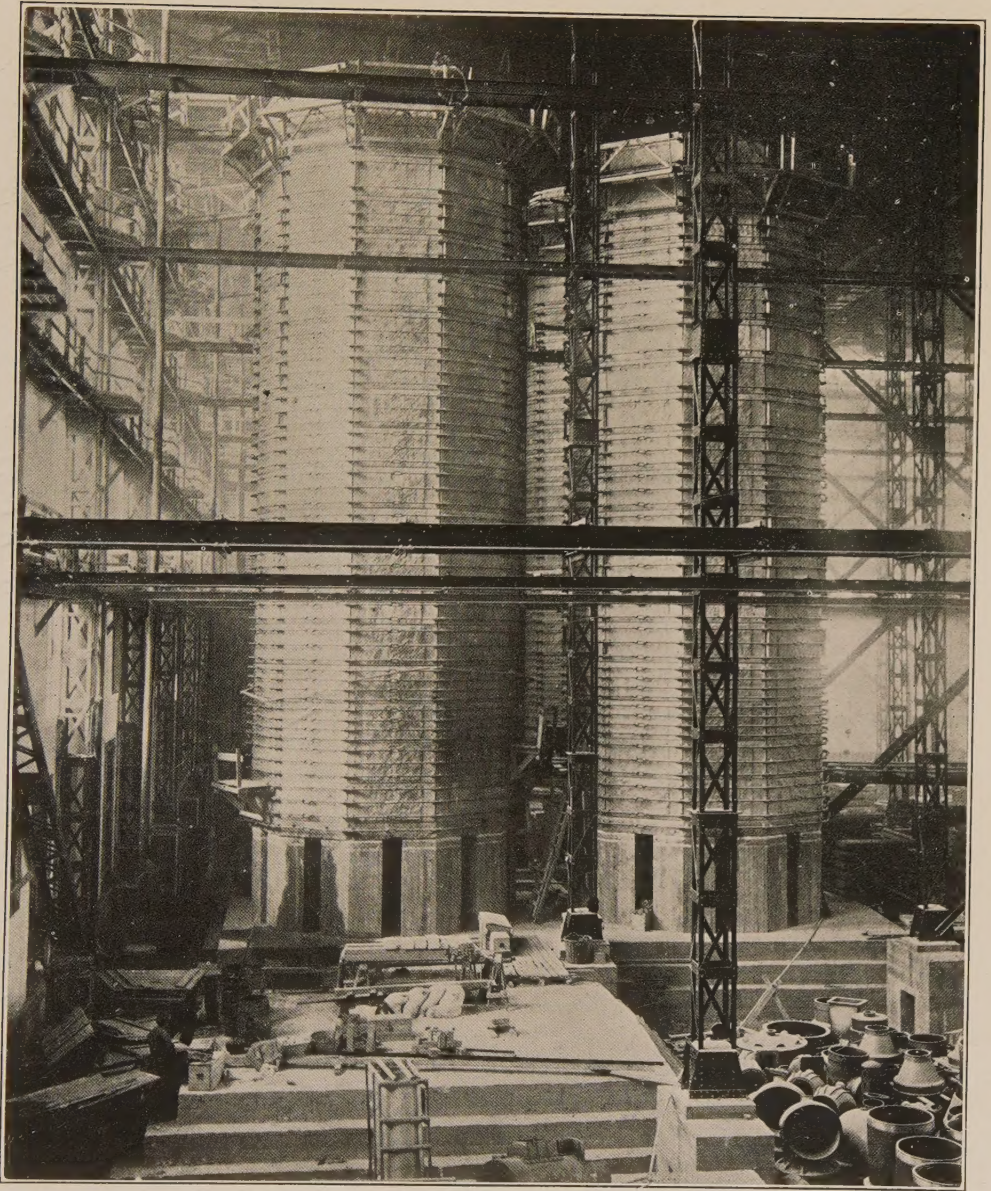
Ammonium nitrate manufacture, Norway. The Saaheim power station.

Applying ammonium nitrate to the soil is really equivalent to making a combined application of sulfate of ammonia and of high grade nitrate. All of the compound is capable of being absorbed by plants. It therefore should not have the effect of turning soils acid as does sulfate of ammonia, or tending to make them alkaline like nitrate of soda.

Several experiments have recently been carried out, in various parts of the world, in which ammonium nitrate has been compared with the ordinary fertilizing salts. E. J. Russell, writing in the *Journal of the Board of Agriculture*, described a series of field tests at Rothamsted and other parts of England. Potatoes, mangolds, and wheat were the crops grown and ammonium nitrate was in each case compared with sulfate of ammonia. The results of these experiments show that the new nitrate is a valuable fertilizer. It was more effective than the sulfate on mangolds and equally effective on wheat. The nitrate appeared to be somewhat inferior to the sulfate for potatoes.

Bachelier in France compared ammonium sulfate, ammonium nitrate, and sodium nitrate in field experiments upon sugar beets. Ammonium nitrate gave equally good results per unit of nitrogen.

Hendrik in Scotland recently compared calcium nitrate, sodium nitrate, ammonium sulfate, ammonium nitrate, and cyanamid. He grew crops of hay and oats on several different soils and obtained at least as good results with ammonium nitrate as with the other forms of nitrogen.



Granite towers in which the nitric oxides are combined with waters during the formation of the nitric acid.



Rjukan factories and town in the background.

Malpeany in France made pot tests on sugar beets, oats, and potatoes, with sodium nitrate, calcium nitrate, ammonium nitrate, ammonium sulfate, and cyanamid. In these tests calcium nitrate gave the best results, followed by sodium nitrate, and cyanamid, only slightly lower.

Only one experiment with ammonium nitrate on sugar cane has been reported. This was made by Easterby in Queensland. He compared dried blood, sulfate of ammonia, calcium nitrate, ammonium nitrate, and nitrate of soda. The fertilizers were applied to the plant crop at the rate of 100 pounds of nitrogen per acre. The yield in tons of sugar per acre was as follows: dried blood 8.5; ammonium sulfate 7.9; calcium nitrate 7.8; ammonium nitrate 7.4; and nitrate of soda 7.3 tons, respectively.

The above experiment was not carried out on Hawaiian soil, but tests under way at the Waipio Substation indicate that ammonium nitrate is a fitting substitute for nitrate of soda. The new material, without doubt, deserves a thorough trial.

G. R. S.

SUGAR PRICES FOR THE MONTH

Ended January 31, 1921

		96° Centrifugals		Beets	
		Per Lb.	Per Ton.	Per Lb.	Per Ton.
Jan.	3, 1921*	5.385¢	\$107.70		
"	4.....	5.520	110.40	No quotation.	
"	7.....	5.510	110.20		
"	8.....	5.520	110.40		
"	11.....	5.550	111.00		
"	12.....	5.520	110.40		
"	17.....	5.515	110.30		
"	18.....	5.425	108.50		
"	19.....	5.390	107.80		
"	21.....	5.385	107.70		
"	22.....	5.390	107.80		
"	25.....	5.270	105.40		
"	26.....	5.135	102.70		
"	27.....	4.930	98.60		
"	28.....	4.890	97.80		
"	29.....	4.885	97.70		
"	31.....	4.855	97.10		

* The previous fluctuation was that of December 28, 1920, when the price changed from 5.31 to 5.32 cents.

[D. A. M.]

